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Cost Estimating for Contaminated Sediment Treatment – A Summary of the State of the Practice

PURPOSE: This technical note reviews the state of the practice for estimating the costs of contaminated sediment treatment and illustrates the state of the practice with several examples. Limitations of composite unit cost comparisons are identified and discussed. The scope of this technical note does not include costs for capping or in situ treatment, and treatment effectiveness is not addressed.

BACKGROUND: Various treatment technologies potentially applicable to contaminated dredged material have been and are being investigated at bench-, pilot-, and demonstration scale (Averett et al. 1990, Santiago and Pelletier 2001, Jones et al. 2001, Wenning et al. 2001). Most have not been commercialized or extensively used at a commercial scale, and there is some uncertainty about projected costs. Composite unit costs extrapolated from case studies range from a low of approximately $30/cubic yard (cy) to over $500/cy. Composite unit costs of this range with their associated uncertainty are not particularly useful to policy or decision makers dealing with hundreds of thousands to millions of cubic yards of contaminated sediment, nor are unit costs particularly helpful to cost engineers working on a project unless they have first-hand knowledge of the case studies, cost elements reported, and conditions that impacted costs. Costs associated with dredging, transportation, pretreatment, treatment, permitting, monitoring, and management of residuals are usually not estimated or well-defined for bench and pilot-scale studies, and detailed cost data are limited for the few demonstration- and commercial-scale projects that have been conducted.

INTRODUCTION: Estimates of the size of the contaminated sediment problem vary widely and have a high degree of uncertainty. The U.S. Environmental Protection Agency (USEPA) (1998) estimates that approximately 10 percent of the sediment underlying U.S surface water is sufficiently contaminated with toxic pollutants to pose potential risks to fish and to humans and wildlife who eat fish. This represents about 1.2 billion cy of contaminated sediment out of the approximately 12 billion cy of total surface sediments (upper 5 cm). In many locales, contamination extends well beyond 5 cm in depth, and removal of only the first 5 cm is usually not cost-effective or acceptable to resource agencies. The USEPA also estimates that approximately 20 percent of National Priorities List (NPL) sites have contaminated sediment (U.S. Environmental Protection Agency 2004). In addition, approximately 300 million cy of sediment are dredged each year to maintain harbors and shipping channels, and somewhere in the range of 3 to 12 million cy of this material is sufficiently contaminated as to be unsuitable for unrestricted open-water disposal (Committee on Contaminated Marine Sediments 1997). The combined uncertainty about the volume of contaminated sediments and the costs of decontaminating sediments is very perplexing for planners and decision makers.

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The cost of ex situ sediment treatment is important to the Corps of Engineers because the Corps and ports must manage increasing amounts of contaminated dredged material from maintenance dredging projects each year. Controversy over adequate management, confinement versus treatment, and treatment costs can impact waterborne commerce by delaying or stopping dredging projects.

STATE OF THE PRACTICE: Contractors use one or a combination of three basic methods to develop estimates for proposals submitted to the Government -- analogous, standard build-up, and parametric estimating (U.S. Department of Defense 1999, U.S. Department of the Army 2002). These methods are described in the following sections and summarized in Table 1.

Table 1
Types of Cost Estimation Techniques[1]

Technique	Description	Advantages	Limitations
Analogy	Compare project with past similar projects	Estimates are based on actual experience	Truly similar projects must exist
Build-Up	Each component is assessed and then component estimates are summed to calculate the total estimate	Accurate estimates are possible because of detailed basis of estimate; promotes cost tracking	Methods are time-consuming; detailed data may not be available; important costs are sometimes disregarded
Parametric Models	Perform overall estimate using design parameters and mathematical algorithms	Models are usually fast; they are also objective and repeatable	Models can be inaccurate if not properly calibrated and validated; relevant historical data required

[1] From U.S. Department of Defense (1999).

Analogy Methods. Analogy methods are the simplest form of estimating. Analogy compares a new project to a completed one for which the cost and schedule are known. The analogy method can also estimate costs by deriving factors to relate costs based on similarities between projects that are not exactly the same. For example, the unit cost (year 2000) for dredging, mechanical dewatering, and disposal of PCB-contaminated sediment from Deposits N and O on the Fox River, WI, was $525/cy (Forth and Van Dyke 2000). Included in the cost were engineering design, public outreach, construction contracting, disposal in a local landfill, construction oversight, and access agreements. By analogy, a similar project on the Fox River would be expected to cost $525/cy or less. A planner might take into account the “learning curve” phenomenon and thereby expect a somewhat lower cost. In 2001, the unit cost for dredging, mechanical dewatering, and landfill disposal of sediment from SMU 65/57 on the Fox River was $366/cy (Montgomery Watson 2001). Future projects on the Fox River of a similar nature might actually cost less.

The analogy method is suitable for planning-level estimates of composite unit costs such as in the example given above. However, analogy estimating has limited use in research and development programs where innovation is a prerequisite for participation. Innovation implies that truly similar projects are not available for comparison, and the technologies are unproven in terms of technical and cost performance. A vendor developing a specific project proposal for sediment treatment would most likely use the build-up method described below.

Build-up Method. This is a method of estimating characterized by a thorough, detailed analysis of all tasks, components, and assemblies. The results are rolled up to produce an estimate of the entire project. Tetra Tech and Averett (1994) used the build-up method to develop cost estimates for treatment and disposal of New York/New Jersey (NY/NJ) Harbor sediments. They used the following cost categories commonly used by the USEPA Superfund Innovative Technology Evaluation (SITE) Program:

- *Site Preparation.* Includes site design and layout, surveys and site logistics, legal searches, access rights and roads, preparation of support facilities, decontamination facilities, utility connections, and auxiliary builds.
- *Permitting and Regulatory Requirements*. Includes following regulatory procedures, obtaining permits, and conducting public meetings.
- *Capital Equipment*. Includes major equipment items, process equipment, residual handling equipment, and associated equipment depreciation.
- *Start-up and Fixed Costs*. Includes equipment installation, mobilization, and preoperational testing.
- *Pretreatment of Waste*. Includes required waste pretreatment before processing. In some cases, pretreatment costs are included in the processing costs.
- *Labor Costs*. Includes supervisory and administrative staff, professional and technical staff, operations personnel, and clerical support.
- *Consumables, Supplies, and Utilities*. Includes utilities such as fuel and electricity, supplies, and raw materials.
- *Effluent Treatment and Disposal*. Includes wastewater and off-gas treatment and disposal.
- *Monitoring and Analytical Costs*. Includes start-up monitoring, operations monitoring, and laboratory analyses.
- *Maintenance and Repair Costs*. Includes maintenance, labor, and materials.
- *Site Demobilization and Cleanup*. Includes shutdown, site cleanup and restoration, permanent storage costs, and site security.

The above cost categories will have different requirements depending on the treatment technology under consideration. Note that dredging is not included in the SITE cost categories listed above. Tetra Tech and Averett (1994) performed cost analyses for six treatment technologies. Table 2 is an example of one of their detailed build-up cost estimates.

Tetra Tech and Averett (1994) included a dredging cost of $7.5/cy (1992 dollars). This is the typical cost for maintenance dredging in NY/NJ Harbor. Environmental dredging usually costs more than maintenance dredging due to added monitoring and restrictions such as silt curtains. In addition, environmental dredging often involves specialty dredges whose cycle times are longer and production is significantly less than that for dredges used in maintenance dredging of navigation channels. A temporary storage facility (TSF) was included in the example given in Table 2 because dredging can be most efficiently performed at a rate that exceeds the rate that dredged material could be treated. A TSF also acts as an equalization basin that evens out variations in dredged material properties and provides a convenient location for debris removal.

Table 2
Example Build-up Cost Analysis: Thermal Gas Phase Reduction Process[1]

Item/Activity	Type of Cost	Present Value[2] 1992 $,000 Total Volume Treated 10,000 cy	50,000 cy	100,000 cy
Site preparation	Fixed	100	100	100
Permitting and regulatory	Fixed	100	100	100
Capital equipment	Variable	247	1,005	1,837
Start-up and fixed costs	Fixed	100	100	100
Pretreatment[3]	Variable	0	0	0
Labor	Variable	346	1,675	3,214
Consumables, supplies, and utilities	Variable	2,573	12,443	23,879
Effluent treatment and disposal	Variable	49	239	459
Monitoring and analytical	Variable	197	957	1,837
Maintenance and repair	Variable	49	239	459
Site demobilization and cleanup	Fixed	98	92	84
Dredging	Variable	75	375	750
Transportation to TSF[4]	Variable	150	750	1,500
Construction of TSF	Variable	300	1000	1,800
Land lease for TSF	Variable	5	52	247
Land lease for process equipment	Variable	3	13	25
Disposal of residual material	Variable	0	0	0
Landfill disposal	Variable	666	3,220	6,179
Total		5058	22,360	42,570
Composite Unit Cost		$506/cy	$447/cy	$426/cy

[1] From Tetra Tech and Averett (1994).
[2] Present value analysis is discussed later.
[3] These costs were implicit in other costs in this example.
[4] TSF = Temporary storage facility.

Advantages of the build-up method are that it provides a detailed basis for costs and can be useful for cost tracking, since separate estimates are established for the activities that will be performed. Cost tracking is an advantage because required activities that are not included can be readily identified. If the basis of the estimate is explicitly documented, it is easier to update the estimate and provide a verifiable trace to a new cost baseline. Build-up cost estimating, however, tends to be time and labor intensive. Data are not always available to support the estimates, and there is a tendency to rely on judgment.

Parametric Cost Estimating. Parametric techniques are based on statistical relationships and mathematical expressions of varying degrees of complexity that are used to estimate the cost of an item or activity as a function of one or more relevant independent variables (U.S. Department of Defense 1999, Environmental Cost Engineering Committee 2002). Parametric models make extensive use of databases that catalog program technical and cost history. The aerospace industry has used parametric models for estimating aerospace program costs including launch vehicles, upper stages, engines, and spacecraft (National Atmospheric and Space

Administration 2002). In a sense, parametric methods are sophisticated-expanded analogy methods in that both rely on relevant experience to develop costs without the time and labor expense of the build-up method. At present, there are no examples of parametric models for sediment treatment costs. However, like the development of space programs, the development of innovative sediment treatment technologies involves substantial investment in research, development, and testing, and parametric estimating may eventually have application to sediment treatment research and development programs.

COMPOSITE UNIT COST COMPARISONS: Because of differences in the unit operations employed by various treatment technologies, it is not always appropriate to apply all of the cost categories shown in Table 2 to all technologies. However, explicit documentation of which cost categories are included in a cost estimate and how the costs for each category were arrived at is needed so that a common basis for cost comparisons among different technologies can be developed. Tetra Tech and Averett (1994) did this in developing their cost estimates.

Wargo (2002) compiled projected composite unit costs for the technologies tested in the Water Resources Development Act (WRDA) sediment decontamination program for NY/NJ Harbor. Technology descriptions with documentation on projected costs are available at Metcalf and Eddy, Inc. (1997, 1998); McLaughlin, Dighe, and Ulerich (1999); Rehmat et al. (1999); JCI/UPCYCLE Associates, LLC (2002); NUI Environmental Group, Inc. (2002), and Biogenesis Enterprises and Roy F. Weston, Inc. (1999). Some of the WRDA technology reports provide a detailed cost analysis for the projected unit costs and some do not. Table 3 lists the projected composite unit costs for treatment and, for comparison, the unit cost for treatment extracted from Tetra Tech and Averett (1994). Projected unit costs developed by Minergy (2003) for vitrification of Fox River dredged material are also included in Table 3. The costs shown in Table 3 do not account for possible beneficial use of treated dredged material and corresponding potential cost recovery.

The WRDA and Minergy (2003) estimates are considerably lower than those estimated by Tetra Tech and Averett (1994), especially if inflation is accounted for. Some consideration therefore must be given as to why there is such a large difference. Direct comparison of the WRDA, Minergy (2003), and Tetra Tech and Averett (1994) estimates is problematic because of incompatible assumptions, inconsistent cost category lists, poorly defined cost drivers, and inconsistent economic methodologies. These incompatibilities result in the apples-and-oranges syndrome. Nevertheless, an attempt at reconciliation is in order. To this end, the following discussion identifies five factors that affect cost estimates and how they might affect the reported numbers.

Scale. The Tetra Tech and Averett (1994) and WRDA projected cost estimates are based on limited bench and pilot scale testing and in a few cases demonstration scale testing. The Minergy (2003) estimate is based in part on prior sediment testing conducted at pilot-scale for the SITE program. In general terms, the scales at which the treatability studies were conducted and projected costs for treatment were derived are similar.

Table 3
Projected Composite Unit Costs for Treatment

Source	Technology	Basis of Estimate: 100,000 cy Job[1]	500,000 cy/yr for 30 years[2]	175, 000 cy/yr for 15 years[3]
Tetra Tech & Averett (1994)	Solidification/stabilization	$195/cy		
	Solvent extraction	$219/cy		
	Bioremediation	$270/cy		
	Base catalyzed dechlorination	$313/cy		
	Thermal gas-phase reduction	$426/cy		
	Rotary kiln incineration	$1285/cy		
WRDA NY/NJ	Permanganate oxidation & S/S[4]		$30/cy	
	Soil washing[5]		$29-35/cy	
	Cement-lock[6]		$60/cy	
	Vitrification[7]		$85-$112/cy	
	ISDS[8]		$31- $42/cy	
	Rotary kiln incineration[9]		$42/cy	
Minergy (2003)	Vitrification			$37/cy

[1] 1992 U.S. dollars.
[2] 1998 - 2001 U.S. dollars, depending on the technology.
[3] 2002 U.S. dollars.
[4] NUI Environmental Group, Inc. (2002).
[5] Biogenesis Enterprises and Roy F. Weston, Inc. (1999).
[6] Rehmat et al. (1999); cost as per Wargo (2002).
[7] McLaughlin, Dighe, and Ulerich (1999).
[8] ISDS: Integrated sediment decontaminatin system, Metcalf and Eddy (1998).
[9] JCI/UPCYCLE Associates, LLC (2002).

However, the projected cost estimates are based on quite different volumes of sediment to treat and time scales for treatment. The Tetra Tech and Averett (1994) estimates are based on a 100,000-cy, one-time job. Throughput rate was not restricted, so that the time required for completion (years in some cases) varied with the equipment available at the time of the estimate. The WRDA cost estimates are based on a fixed plant life of 30 years with a minimum sediment throughput of 500,000 cy/year, and the Minergy (2003) estimate is based on a fixed plant life of 15 years with a throughput of 175,000 cy/year. There is therefore a difference in scale between the Tetra Tech and Averett (1994) treatment units and the WRDA and Minergy (2003) estimates. The Tetra Tech and Averett (1994) processing equipment is small relative to that reflected in the WRDA and Minergy (2003) estimates. Since unit capital and unit operations and management costs are typically inversely proportional to the equipment size, an economy of scale is reflected in the lower estimates for WRDA and Minergy (2003).

Partial costing. Partial costing refers to the intentional, i.e., stated, or unintentional disregard for certain cost categories in developing a composite unit cost estimate. For illustration, the Minergy (2003) estimate is discussed. This is followed by a general discussion of the cost categories addressed in the estimates listed in Table 3.

Minergy (2003) used the standard build-up method to prepare a revised unit cost study for the Wisconsin Department of Natural Resources (WDNR) for treating sediment with their glass furnace technology. The original study was part of a demonstration for the USEPA SITE Program. (The WDNR web site includes a description of glass furnace technology, www.dnr.state.wi.us/org/water/wm/lowerfox/). The purpose here is not to criticize the cost estimate developed by Minergy, but to point out the value of detailed and explicit activity/cost documentation that is the basis of build-up methods. Explicit documentation provides a basis for developing updated estimates using current or site-specific cost data. Minergy (2003) provided documentation of how the costs were arrived at for each cost category and stated all the assumptions used in developing the cost estimate, including the assumption that dewatered dredged material cleaned of debris would be delivered to the treatment plant for processing. Pretreatment costs were explicitly excluded. Since dewatering and debris removal are necessary activities for the Minergy technology, the Minergy (2003) estimate could be updated by adding an estimate of dewatering and debris removal costs. Such an estimate should be site-specific and tailored to the plant size proposed by Minergy (2003).

Some of the USEPA SITE cost categories used by Tetra Tech and Averett (1994) were not included in the WRDA and Minergy cost estimates. Table 4 lists the cost categories that were documented in the various cost estimates.

The cost analyses by NUI Environmental Group, Inc. (2002) and Minergy (2003) contained detailed cost by category and explicit assumption sets. The cost analyses by Biogenesis Enterprises and Roy F. Weston, Inc. (1999) and JCI/UPCYCLE Associates, LLC (2002) were rough estimates of unit costs for the categories checked in Table 4. There were no details and few explicit assumptions. In their reports, Rehmat et al. (1999) and McLaughlin, Dighe, and Ulerich (1999) indicated that a cost analysis would be prepared in future efforts. The Metcalf and Eddy (1998) cost analysis was detailed for the categories checked, but there were few explicit statements about assumptions.

The cost categories included, the level of detail included, and the assumptions stated varied widely among the cost estimates, and the cost categories included in an estimate directly affect the final composite unit cost. The major cost categories are capital and operations and management (O&M) costs, and all the estimates include these costs. The scale of the project affects the significance of excluding some cost categories. Land acquisition, permitting, legal fees, and engineering services have a more pronounced effect on the composite unit cost for small-scale projects than for large-scale projects.

Economic methodology. Tetra Tech and Averett (1994) and Minergy (2003) conducted a present value analysis and the discount rates they used were 4.4 and 5 percent, respectively. O&M costs were discounted over the operating life of the treatment plants. Capital costs were treated as a one-time sunk cost. Present value analysis is often used in the economic analysis of projects that extend into the future and is described in U.S. Department of the Army (2002), National Atmospheric and Space Administration (2002), and many textbooks on economic analysis. The present value concept accounts for the fact that money in hand today is more valuable than money or benefits received in the future and is particularly useful for comparing

Table 4
Cost Categories Comprising Projected Composite Unit Costs

Cost Item/Activity	Technology						
	PO	SW	CL	VIT	ISDS	RKI	Minergy
Site acquisition and preparation	√		?	?			
Permitting and regulatory	√		?	?			
Capital equipment	√	√	?	?	√	√	√
Start-up and fixed costs	√		?	?			√
Pretreatment	√		?	?	?	√	
Labor	√	√	?	?	√	√	√
Consumables, supplies, and utilities	√	√	?	?	√	√	√
Effluent treatment and disposal	?		?	?		√	
Monitoring and analytical	√	√	?	?	√	√	
Maintenance and repair	√	√	?	?	√		√
Site demobilization and cleanup			?	?			
Disposal of residual material	NA	√	?	?	√	√	
Landfill disposal of debris	√		?	?	?	√	

PO: permanganate oxidation & S/S, NUI Environmental Group, Inc. (2002).
SW: soil washing, Biogenesis Enterprises and Roy F. Weston, Inc. (1999).
CL: Cement-Lock®, Rehmat et al. (1999).
VIT: Vitrification, McLaughlin, Dighe, and Ulerich (1999).
ISDS: integrated sediment decontamination system, Metcalf and Eddy (1998).
RKI: Rotary kiln incineration, JCI/UPCYCLE Associates, LLC (2002).
NA: TSF either incorporated into pretreatment cost or need for TSF not anticipated.

alternatives when costs and benefits are distributed over time. The manner in which the present value analysis is conducted is important, and for comparison of alternatives, present value analysis should be done in a consistent manner. Present value analysis uses discount rates to calculate the present value of future costs and benefits. Office of Management and Budget (OMB) Circular A-94 provides specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time.

NUI Environmental Group, Inc. (2002) amortized capital, installation, engineering and design costs using an interest rate of 7 percent over either a 30-year period or a 7-year period, depending on the cost category. Operation and maintenance costs were not discounted. This is quite different from treating initial costs as sunk costs and discounting annual O&M. Metcalf and Eddy (1998) took a completely different tack for their cost analysis. They estimated capital cost as somewhere between $10 million and $20 million without a detailed analysis of the capital cost drivers, but capital costs were not treated as a one-time sunk cost. They then estimated other costs on an annual basis as a percentage of the initial capital investment. They provided a detailed breakout of all the costs that were estimated as a percentage of the capital investment. To the sum of all the annual costs that were calculated as a percentage of the capital investment, they added a fixed 10-percent depreciation of the capital investment to capture the capital investment cost. Some of their costs were arrived at without a formal economic analysis or at least the analysis was not documented.

The documentation for the other WRDA technologies did not indicate how the time value of money was accounted for.

In short, the economic tools that have been used to estimate composite unit costs for sediment treatment facilities are as varied as the cost categories included in the analysis. The level of detail at which the economic tools were described varied widely also. At worst, the accuracy of composite unit costs so generated is uncertain, and at best, they are based on inconsistent and incompatible assumptions and analysis. The available estimates vary widely in how the changing value of the dollar over time is dealt with, and this has a significant effect on the composite unit cost estimates.

Learning curve. Learning curve theory states that as the quantity of a product increases, the manufacturing hours per unit expended producing the product decrease. The learning curve, as originally conceived, analyzes labor hours over successive production units of a manufactured item. The theory has been adapted to account for cost improvement across an organization. Both cost improvement and the traditional learning curve theory are defined by the following equation (U.S. Department of Defense 1999):

$$Y = AX^b$$

where:

Y	=	hours/unit (or constant dollars per unit)
A	=	first unit hours (or constant dollars per unit)
X	=	unit number
	=	slope of the curve related to learning

The basic idea is that the organization improves its efficiency and cost improvement occurs with additional experience. In a mature technology area, cost reduction with additional experience is small until there is a technological breakthrough. At that point the learning process starts over again. For an immature technology area such as sediment decontamination, technological breakthroughs are part of the learning process.

Cost estimates by vendors that have been working on sediment treatment technology or related areas for some time probably reflect the efficiencies that they have learned. The significance of this effect on the cost differentials between the estimates of Tetra Tech and Averett (1994) and the more recent estimates is difficult to evaluate. At this point we have no firm examples of the learning curve theory actually being employed to project future economies and costs for sediment treatment, and it is probably too early in the game to project what efficiencies, technical breakthroughs, and cost reductions may occur in future years. But learning curve theory suggests that such things will happen; possibly across the whole technology area.

Source. Commercial vendors are the primary source for cost data, including the estimates of Tetra Tech and Averett (1994), which were developed using cost data from vendors. The following is a quote from the NASA Cost Estimating Handbook (National Atmospheric and Space Administration 2002): "…their motivation shifts based upon the different phases of acquisition. During pre-award, commercial vendors are motivated to win business, working hard to keep their cost estimates competitive. After award, a commercial vendor's motivation shifts

to profitability, alleviating some of the pressure on cost accuracy." Because of this dynamic, specifying an estimating methodology is an important early step in obtaining consistent and credible cost estimates. It would be prudent, therefore, to establish policy and procedures for a consistent and visible cost estimating framework prior to requesting cost estimates for sediment treatment projects that may last many years.

BENEFICIAL USE COSTS IN NY/NJ HARBOR: S/S has already found full-scale application in the region, with land and/or Brownfield remediation as the primary beneficial use. Large-scale beneficial use of processed dredged material as construction fill has been successfully demonstrated at several sites, and the potential for using processed dredged material in strip mine reclamation has been investigated in other demonstration projects. Different formulations of various binders have been used, including Portland cement, cement kiln dust, lime kiln dust, lime, and coal fly ash. The primary purpose of the binders is to react with water, and thereby dewater the dredged material to create a soil-like material that is suitable for use as fill material. The success of these waterfront Brownfields reclamation/dredged material projects revolves around a critical need for innovative dredged material disposal options, aggressive pursuit of innovative dredged material management by local and state government, the high cost of transporting conventional fill material in highly congested areas, and the availability of waterfront Brownfields for redevelopment.

Two of the more notable projects are the Jersey Gardens Mall site and the Bayonne site, both in New Jersey. At the Jersey Gardens Mall site, approximately 500,000 cy of dredged material was amended with binders and used to cap an old sanitary landfill. The site was then developed into the third-largest mall in New Jersey. The cost was about $48/cy for dredging, processing, transport, and placement. The Bayonne site encompasses a Brownfield (as well as an inactive landfill). As of December 2003, the site had accepted approximately 3 million cy of dredged material for use in the remediation of the site. Costs (including dredging, processing, transport, and placement) at the Bayonne Site run $40-50/cy. This site is being developed into a golf course.

Another beneficial use site is the Port Liberte Brownfield site located in Jersey City, NJ. The site accepted approximately 200,000 cy of dredged material at a cost of approximately $29/cy. Dredged material was amended offsite and trucked to the Port Liberte site for use as structural fill for a proposed golf course.

Additional Brownfield sites in New Jersey are being considered for their suitability in using amended dredged material as fill material. NJDOT/OMR has estimated that project costs (excluding dredging and transportation) for the majority of the Land Remediation projects, including treatment and transport to the site, will be $29-32/cy.

It is not clear how much of the costs for permitting, testing, processing, etc. have been borne by the land developers. Thus, some of these costs are still uncertain, but it is expected that technological advances and market economics will select the most effective and efficient operations as land redevelopment projects continue.

CONCLUSIONS: Cost estimates for sediment treatment are applicable to only the conditions and constraints for which the estimate was prepared. Land acquisition costs, project scale, and beneficial use opportunities can significantly affect cost estimates and are highly site-specific.

Detailed activity/cost documentation has not always provided for sediment treatment cost estimates, and without such information, one cannot know which activities were included in the cost estimate, the cost drivers and parameters for each category, and the economic analysis tools that were used. If the basis of the estimate is explicitly documented, it is easier to update the estimate and provide a verifiable trace to a new cost baseline as key assumptions change during the course of a project lifetime. If the details or assumptions are wrong, then estimates will be flawed and reconciliation with actual cost will be difficult.

Composite unit cost comparisons suffer from inconsistent application of economic analysis tools, especially the methodology for accounting for the time value of money. Aside from variations in the cost categories included in an economic analysis, the way the numbers are then manipulated to deliver a composite unit cost estimate vary widely. The combined effect is one of "apples and oranges."

Of the various factors affecting composite unit cost estimates, two factors, scale and partial costing, probably account for most of the discrepancy between the Tetra Tech and Averett (1994) cost estimates and the other cost estimates.

RECOMMENDATIONS: Reliable cost estimates will be developed only through execution and reporting of multiple full-scale sediment treatment projects over a period of years. Until such time that a track record is established for commercialization of sediment treatment technology, guidance is needed for preparing cost estimates so that they comply with sound estimating techniques, good judgment, and consistent estimating methodology. Policy and procedures should be established for a consistent and visible cost-estimating framework for sediment treatment with sufficient detail and coverage of all cost categories. The purpose of such a framework would be to provide government agencies, private industry, and the public with accurate, reliable, and defensible cost estimates.

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